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HYBRID COHERENT-OPTICAL, RF SIGNAL CHANNELIZER

CROSS REFERENCE TO RELATED APPLICATIONS

This application is related to commonly owned co-pending patent application, Serial No. 08/759,901, filed on December 4, 1996, entitled "All Optical RF Signal Channelizer," by Wickham, et al.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to an optical channelizer system and more particularly to an optical channelizer system adapted to provide RF signal channelization at frequencies in the order of 100GHz or more which instantaneously channelizes the entire signal spectrum into channels having a few megahertz.

Description of the Prior Art

Various factors are driving communications systems toward higher frequency and larger bandwidth. For example, available communications bandwidth is disappearing as the number

of users and the bandwidth per user escalates forcing communication links to higher frequencies. In addition, newer communication systems, such as military communications are increasingly being driven toward higher frequencies and larger bandwidth user requirements. For example, modern missile seekers and imaging radar systems are utilizing frequencies around 100 GHz to achieve antenna directivity and higher resolution for small aperture systems. In order to accommodate relatively high bandwidth and high frequencies, RF communications systems are known to employ optical carrier transmission of the RF signal. Examples of such systems are disclosed in U.S. Patent No. 4, 468,766; 4,695,790; 5,005,946; 5,347,535; 5,377,035 and U.S. Statutory Invention Registration H1059.

Optical channelizers are used to perform spectral analysis of the newer high frequency communication signals. Such optical channelizers are known to process relatively wider bandwidth than comparable RF channelizers for real time identification of complex signals. Such optical channelizers are used in particular to channelize or divide up a relatively wide bandwidth signal into several subbands or channels. Although such optical channelizers are known to process relatively wider bandwidth than known RF channelizers, many optical channelizers utilize acousto-optic technology which limits the bandwidth to a few gigahertz. Examples of optical communications systems utilizing acousto-optic technology are disclosed in U.S. Patent No. 4,448,494; 4,644,267; 5,005,946; 5,105,380; 5,327,142 and 5,363,221.

In order to resolve this problem, optical channelizers have been developed which do not depend on the acousto-optic technology as disclosed in commonly owned co-pending U.S. patent application Serial No. 08/759,901 filed on December 4, 1996. In that application, as illustrated in Figs. 1 and 2, an optical channelizer, generally identified with the reference numeral 20 includes a diffraction grating. The RF signal spectrum, generally identified with

the reference numeral 22, is spatially mapped to positions across a 1xn photo-detector array 24 by the diffraction grating. A mode locked laser 26 provides a comb of optical local oscillator (LO) frequencies 28 (Fig. 2), separated by the desired channel spacing. The LO signals are optically heterodyned with the signal spectrum at the photo-detector array 24. In this way, each detector generates the same band of optical frequencies so that each channel may use the same post detection electronics. The band is centered on an intermediate frequency (IF) that is determined by adjusting the offset (Fig. 1) in the incident angles at which the signal and the local oscillator lasers illuminate the grating. A complex signal spectrum (phase and amplitude) is extracted by measuring the in-phase and quadrature components of the heterodyne products. Each detector is followed by a IF filter whose bandwidth is generally set to the channel spacing in order to achieve a hundred percent frequency coverage. Unfortunately, due primarily to size constraints, the optical channelizer, disclosed in the '901 patent application, is limited to minimal channel bandwidth of about 1GHz. Although it is possible to improve the channelizer sensitivity, dynamic range and resolution by reducing the bandwidth of the post detection IF filter, such an approach compromises the frequency coverage. For example, a 1 GHz channelizer with 40 MHz IF only detect signals within the IF filters pass band, thus being blind to 960 MHz out of every 1 GHz of bandwidth or 96% of all possible signals. Thus, there is a need for an optical channelizer for use with signals up to 100 GHz with improved resolution.

SUMMARY OF THE INVENTION

The present invention relates to an optical channelizer system that is adapted to provide instantaneous RF signal channelization at frequencies on the order of 100GHz or more into channels having bandwidth as small as a few megahertz. In order to improve the channel

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resolution the optical channelizer system is formed from a plurality of parallel channelizers, for example, twenty-five parallel sub channelizers which can provide 1 GHz channel spacing and 40 MHz signal resolution.

DESCRIPTION OF THE DRAWINGS

These and other advantages of the present invention will be relatively understood with reference to the following specification and attached drawing, wherein:

Fig. 1 is a conceptual diagram of a known optical channelizer.

Fig. 2 is a physical drawing of the optical channelizer illustrated in Fig. 1.

Fig. 3 is a physical diagram of an optical channelizer in accordance with one aspect of the present invention illustrating the use of a Bragg cell for replicating the signal spectrum.

Fig. 4 is a physical diagram of the optical channelizer in accordance with illustrating the use of the present invention a monolithic optical splitter/amplifier integrated circuit (MOSAIC) for splitting the LO signals.

Fig. 5 illustrates the invention utilizing the MOSAIC as well as the Bragg cell.

DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to an optical channelizer system that is adapted to provide RF signal channelization at frequencies on the order of 100 GHz or more which simultaneously channelizes the signal spectrum into channels having bandwidths as small as a few MHz. The optical channelizer system in accordance with the present invention is adapted to provide improved resolution while at the same time maintaining a suitable physical size so that it is deployable on various terrestrial and airborne platforms. In particular, as illustrated in Figs. 3-5, the optical channelizer system in accordance with the present invention is formed from a

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plurality of subchannelizers, arranged to operate in parallel.

Although, the system is described and illustrated for channelizing signals having a bandwidth of a 100 GHz or more, it will be understood by those of ordinary skill in the art, that the principles of the present invention are broadly applicable to signals having a bandwidth more or less than a 100 GHz. An important aspect of the present invention is that the problems associated with the channelizer illustrated in Figs. 1 and 2 and discussed above are solved by dividing the signal spectrum and the local oscillator comb frequencies prior to applying those signals to an optical channelizer, such as, the optical channelizer 20, discussed above and illustrated in Figs. 1 and 2. However, it should be understood that the principles of the present invention can be utilizing various types of channelizers, such as channelizers based on integrated optical arrayed wave guide gratings, for example, U. S. Patent 5, 943,452.

Referring to Fig. 3, the optical channelizer system in accordance with the present invention is generally identified with the reference numeral 32. The optical channelizer system 32 includes an optical channelizer 20, for example, the optical channelizer 20 illustrated in Figs. 1 and 2 and discussed above, a m x n dimensional photo detector array 34 as opposed to the 1xn detector array used with the channelizer 20, illustrated in Fig. 2, and a source of a local oscillator frequency comb, with the frequencies, separated, for example, by 1 GHz. In order to generate multiple signal beams, the signal spectrum is passed through a Bragg cell 34. Such Bragg cells are generally known in the art. An example of a suitable Bragg cell 34 is disclosed in I. C. Chang, "Acousto-optic Devices and Applications," IEEE Trans-Sonics and Ultrasonics, Vol. 50-23, P. 2 (1976). The Bragg cell 26 can be driven to replicate the signal spectrum to generate, for example, 25 signal beams, with each version of the signal spectrum being shifted, for example, by 40 MHz with respect to its predecessor. As shown in Fig. 3, in order to provide

such separation, a periodic chirp signal, for example 1 GHz, generally identified with the reference numeral 38, is used to drive the Bragg cell 36. In order to replicate the signal spectrum 25 with each version of the signal spectrum frequency shifted by, for example, 40 MHz with respect to its predecessor, the period of each chirp signal is selected to be 1/40MHz or 25ns. The 25 signal beams are applied to the optical channelizer 20 and translated unto the m x n detector array 34. As a result, the image of each signal spectrum is imaged onto a different row of the m x n detector array 34 and translated horizontally. An optical amplifier (not shown) may be used to amplify the signal before it has been replicated 25 times by the Bragg cell 36.

Fig. 4 illustrates a system for spatially dividing the local oscillator input beam, for example 25 times. As shown in Fig. 5, a monolithic, optical splitter/amplifier integrated circuit (MOSAIC) may be used to spatially divide the local oscillator signal. The output of the MOSAIC 30, in turn, is applied to the optical channelizer 20. In particular, the resulting images of the local oscillator spectrum are projected onto horizontal rows of the photo detector array 34. With such an arrangement, each photo detector 34 processes a different 40 MHz segment of the signal with identical post detection electronics. The signal frequencies detected by adjacent elements in a particular row differ by 1GHz. Neighboring rows operate on segments that are displaced by 40MHz and so on for each role until the entire 1GHz is spanned. With such an arrangement a number of subchannelizers are formed and operated in parallel.

Alternatively, the signal spectrum can be replicated identically, for example, by being passed through the MOSAIC 40, while the local oscillator beam is passed through the Bragg cell 36 to generate frequency shifted versions of the LO spectrum. Since it is desirable to maintain the LO spots centered on their respective detectors, the rows of detectors may have to

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be skewed.

Obviously, many modifications and variations of the present invention are possible in light of the above teachings. For example, the invention can be implemented utilizing virtually any type of optical channelizers, such as one based on integrated optical arrayed waveguide gratings. Thus, it is to be understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically described above.

What is claimed and desired to be secured by Letters Patent of the United States is: